WHITE PAPER

ABOVE THE FLOOR MACT
FOR
DIGESTER AND LANDFILL GAS

September 4, 1998

Purpose

The purpose of this document is to present EPA with guidance on the Above-the-Floor technologies that should be considered for further evaluation for controlling hazardous air pollutant (HAP) emissions from reciprocating internal combustion engines burning digester gas and/or landfill gas.

Background

Digester and landfill gases are gaseous by-products, principally comprised of methane and carbon dioxide, of anaerobic decomposition of organic materials. Trace quantities of other compounds are typically found in the gases including hydrogen sulfide and ammonia. In addition, a class of compounds called Siloxanes, which are silicon based compounds found in many cosmetics and cleaning solutions are also present in the gas. These compounds have been known to clog catalysts typically used for post-combustion control of Nitrogen Oxides (NOx).

These fuels are typically recovered by the facility operators and burned in combustion devices such as internal combustion engines to either generate electricity or directly power a pump or blower.

Survey of Population

A survey was conducted by the Association of Metropolitan Sewerage Agencies (AMSA), which represents the nations largest wastewater treatment agencies, in 1997 to identify what internal combustion engines were operating on digester gas and the type, if any, of controls that were installed to reduce HAP emissions. The results of the survey identified 169 engines (both lean and rich burn types) that burn digester gas. Of these 169 engines, two engines reported operating post-combustion control devices, specifically, Selective Catalytic Reduction (SCR). The other 167 engines reported no post-combustion control; however, many of these engines reported having combustion modifications for the control of NOx, including pre-combustion chamber, A/F ratio adjustment or timing adjustment. None of these combustion modifications have any documentation that demonstrates HAPs reductions. The results of this survey do not appear in the current EPA population database. However, AMSA has submitted their database in a format consistent with the EPA database, and EPA has indicated to AMSA that their data will be incorporated into EPA's database in the future.

The EPA population database developed by the Reciprocating Internal Combustion Engine (RICE) Workgroup identified 174 engines that burn either landfill gas or digester gas. Of the 174 engines, 3 burn digester gas. For all three digester gas engines, no controls for HAPs were in place.

Of the 171 engines identified in the EPA population database that burn landfill gas, a small percentage of the engines use an "air injection" emission control system on rich-burn engines. Apparently three landfills in California, operated by the same company, operate 10 rich-burn engines that utilize air injection to reduce Carbon Monoxide (CO) emissions. The Workgroup evaluated this emission control system and consider it inappropriate for reasons discussed in a later section of this White Paper. In addition, one landfill in Orange County has installed a new control technology system that combines a lean burn engine and afterburner flare that treats the exhaust of a lean burn engine. Since the flare operates at a temperature in excess of 1500 degrees Fahrenheit, there is the potential that this technology may reduce HAP emissions, and therefore should be further investigated.

As a result of the Workgroup's review of existing technologies that have been applied on either digester gas or landfill gas engines, this White Paper will briefly summarize the applicability of three HAP control technologies to these fuels. These include catalytic control (NSCR or oxidation), air injection, and afterburner flaring.

Above-The-Floor Control Technologies

Catalytic Control

Publicly Owned Treatment Works (POTWs) have had a history of failed applications of catalytic control on digester gas fired engines. This includes both reductive and oxidative catalysts. The primary problem with catalyst is that a compound called Siloxane, which is silicon based and present in both digester and landfill gases, clogs the catalyst bed reducing the availability of sites where the catalytic reaction can occur, and ultimately renders the catalyst inoperable. It should be noted that installation of a pretreatment system to remove the Siloxane prior to combustion in the engine is possible, and will allow a catalytic control system to operate on digester and landfill gases. However, the cost to install and maintain such a system is substantial and is the reason why these pretreatment systems are not currently operating anywhere in the country. Case in point, a POTW in San Diego, which had installed an SCR system for NOx control on their engine, had installed a pretreatment system, which consisted of water drop out, physical screening and activated carbon, to remove the Siloxane prior to combustion in the engine. The system apparently worked, however, capital and operating costs were high and the facility decided to replace this system (in 1998) with a low- NOx lean burn engine.

Several case studies on the failure of catalytic controls on digester gas fired engines are briefly described below.

1. A report from Malcolm Pirnie (engineering consultant) to New York's Nassau County Department of Public Works is attached. This report describes the reliability

problems with oxidation catalysts applied to digester gas fired engines operating at two different wastewater treatment plants. Based upon testing conducted in 1996, the engines catalyst's performance dropped to 80% efficiency after only 250 hours of operation and it became completely de-activated after approximately 700 hours of operation. The problem was identified as catalyst clogging due to Siloxane. The report also includes a discussion on several other applications of failed catalyst on engines and gas turbines burning digester gas.

2. A report by the City of Los Angeles' (CLA) Technology and Resource Recovery Division on testing of various oxidation catalysts in 1992 treating the exhaust stream of a gas turbine generator. The testing was conducted for the purpose of complying with a local air district rule for criteria pollutants and included an evaluation of seven different catalysts manufactured by five different companies. The study included evaluations of overall catalyst activity after 4,058 hours of service, evidence of physical masking, and evidence of catalyst poisoning. In the tests, the catalysts from two manufacturers failed, one catalyst manufacturer elected not to test the activity of their catalyst, and two catalyst manufacturers reported high catalyst activity after service (Kleenaire for a base metal on ceramic substrate and MetPro for both a base metal on ceramic substrate and precious metal on ceramic substrate). The CLA's conclusion was that a precious metal catalyst on a ceramic bed could work. However two precious metal catalysts on ceramic substrate were tested (Engelhard and MetPro) and one worked and the other failed. The factors that led to the one successful test are not clear. The CLA elected not to install the catalyst so there are no data available to show full scale successful application.

3. A 1984 report by the Los Angeles County Sanitation Districts (LACSD) on NSCR tests conducted on a digester gas fired engine. Conclusions from the test are that the catalyst did not operate reliably and could not meet the emission limits required by the local air district. The exact cause of the catalyst failure was not identified; however, silicon was detected in significant quantities on the catalyst bed.

4. A memorandum (with attached letters from catalysts manufacturers) from the LACSD summarizing catalyst manufacturers rejection to bid on supplying an SCR system for a turbine firing digester gas. Though the application was on a turbine, the important point with this memorandum is the catalyst manufacturers concern over detrimental effects on their catalysts due to contaminants in the digester gas.

Based upon AMSA member agency experience with catalysts, the fact that there are no catalyst controlled digester gas or landfill gas engines successfully operating in the United States, and that pretreatment systems to remove Siloxane are costly to install and maintain; the RICE Workgroup does not believe that catalytic control has proven reliable or cost-effective enough to be considered for above-the-floor MACT controls.

Air Injection for Rich-Burn Engines

There are ten (10) rich-burn, landfill gas fired engines utilizing an air injection emission control technology. These ten engines were originally equipped with NSCR to control NOx emissions. After early failure of the NSCR devices due to catalyst fouling, the operator attempted to meet emission requirements by modifying the operating parameters of the engines. This included running the engine at fuel-rich conditions. This resulted in lower NOx emissions, however, Carbon Monoxide (CO) emissions increased. Air injection into the exhaust stream was then added to control CO emissions.

The facility operator has received several notices of violation between January 1, 1990 and May 21, 1998 for the control systems. At one plant, seven NOx and two CO emission violations were received. At the second plant, five NOx and two CO emission violations were received. It is important to note that the facility operator has decided to replace these ten rich-burn engines with lean-burn engines.

Although the plants do not have actual emission data, there are several theoretical problems with this emission control system. Rich-burn engines operating fuel-rich produce more CO and formaldehyde emissions than engines operating at proper air-to-fuel ratios. The injection of air must be done precisely; if either too much or too little air is injected, both the rate of exhaust gas combustion and the resulting CO reduction efficiency will be affected. Proper mixing of the injected air is also important, since poor air distribution can cause sections of the exhaust gas stream to remain unburned.

Even if the control system is working perfectly, there is no evidence that is will reduce HAP emissions beyond that of a properly tuned engine. Therefore, the RICE Workgroup has determined that the use of fuel-rich/air injection for HAP emission control on rich-burn internal combustion engines is not appropriate.

Landfill Gas Flare-Afterburner

There is a landfill operating in Orange County (Prima Deschecha) that has installed a lean burn engine coupled with a flare-afterburner to meet the landfill gas, 98% destruction efficiency requirement of NSPS Subpart WWW. In addition, the Tajiguas landfill in Santa Barbara County has been issued a permit-to-construct (PTC) by the APCD to install a similar lean burn engine/flare-afterburner system. Based upon the PTC the flare-afterburner will operate in two modes. Its primary mode will be to treat the exhaust gas from the lean burn engine and directly burn a portion of the fugitive landfill gas that is collected and cannot be burned in the engine. The secondary mode of operation is to burn all of the fugitive landfill gas collected when the engine is not operating.

The NSPS Subpart WWW requires the control of Non-Methane Organic Compounds (NMOC). There is no requirement for HAP control. A NOx and Reactive Organic Compound (ROC) Best Available Control Technology (BACT) control cost effectiveness analysis was conducted for the Tajigues landfill PTC. This may have also been done for the Prima Deschecha landfill project; however, the RICE Workgroup did not have any documentation at the time of this White Paper. The economic analysis showed the project to be cost-effective for both NOx ($59/ton removed) and ROC ($1,589/ton removed) control. In the PTC's BACT cost-effectiveness analysis, the $1,589/ton of ROC removed is based on 25 tons/yr of ROC produced by the engine. The important consideration is that the economic evaluation would likely be different if it was based upon HAP destruction since a new lean burn engine of this size (4,314 bhp) burning landfill gas would likely emit substantially less than 25 tons/yr of formaldehyde.

Since the afterburner-flare operates at a temperature in excess of 1500 degrees Fahrenheit, there is the potential that this technology may reduce HAP emissions. In addition, these systems are being installed to comply with NSPS Subpart WWW. Therefore, the RICE Workgroup believes that EPA should further investigate this technology for the control of landfill gas engines.

Conclusion

In summary, the RICE Workgroup does not believe that catalytic controls or air injection for rich-burn engines have proven reliable or cost-effective enough to be considered for above-the-floor MACT controls. We do recommend that EPA further investigate the HAP reduction performance and cost-effectiveness of the lean burn engine/flare-afterburner control system for landfill gas fired engines that is installed at the Prima Deschecha landfill in Orange County, California and soon to be installed at the Tajigues landfill in Santa Barbara County, California.

Supporting Documentation

The following documents that were referenced in this White Paper have been submitted into the NESHAPS RICE docket (A-95-35):

1. Malcolm Pirnie Consultants; Technical Memorandum, Catalyst Performance Investigation; prepared for the Nassau County Department of Public Works; September 1996
2. City of Los Angeles, Department of Public Works, Bureau of Engineering; Technical Report, CO and NOx Mitigation Catalyst Testing and Evaluation; December 1993
3. Los Angeles County Sanitation District; Catalytic Denitrification of Exhaust from Reciprocating Engines Fueled with Sewage Digester Gas; 77th Annual Meeting of the Air Pollution Control Association; June 1984
4. Los Angeles County Sanitation District; Memorandum; Responses to RFP for Correcting TEF/SCR System; July 1996

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